

**Ganymede Northern High Latitude Frosts: Preliminary Observations FROM GALILEO SSI DATA.** R. Pappalardo<sup>1</sup>, J. W. Head<sup>1</sup>, G. Collins<sup>1</sup>, C. Pilcher<sup>2</sup>, P. Helfenstein<sup>3</sup>, J. Veverka<sup>3</sup>, J. Burns<sup>3</sup>, T. Denk<sup>4</sup>, G. Neukum<sup>4</sup>, M. Belton<sup>5</sup> and the Galileo Imaging Team, <sup>1</sup>Dept. Geol. Sci., Brown University, Providence, RI 02912; <sup>2</sup>NASA Headquarters, Washington, DC ; <sup>3</sup>Cornell Univ., Ithaca, NY; <sup>4</sup>DLR, Berlin Germany; <sup>5</sup>NOAO, Tucson AZ.

**Background and Rationale:** One major objective of the Galileo Solid State Imaging team targeting for Ganymede was to observe high latitudes (both globally in color, and locally) to determine the characteristics of the high-latitude and polar brightening that was observed in Voyager data (1-4). Voyager observations showed that there was: 1) a better preservation of bright crater rays at high latitudes (crater materials south of the cap are generally of low to intermediate albedo, interpreted to mean that greater frost ablation occurs there and leaves a silicate-enriched lag; e.g., Shoemaker et al., 1982 (5)), and 2) a continuous diffuse, bright deposit (without relief) known as the polar frost caps or hoods. Several hypotheses were proposed to account for these Voyager observations including:

- 1) Squyres (1980) (1) suggested that water-frost deposits remain longer in the colder environment of the high latitudes.
- 2) Purves and Pilcher (1980) (6) suggested accumulation by cold-trapping of water ice ablated by solar radiation.
- 3) Veverka and Johnson (1982) (7) and Johnson (1985) (4) suggested accumulation by cold-trapping of water ice by bombardment by the Jovian radiation belts, a model supported by Hillier et al. (1996) (8).
- 4) Shaya and Pilcher (1984) (3) suggested that the caps might be a relict deposit formed during the emplacement of light terrain materials.
- 5) Spencer (1987) (9) suggested that sublimation is the most important process for redistribution of ices at a scale less than the Voyager resolution and that frost will be cold-trapped in local bright patches and preferentially depleted from darker, warmer areas. Spencer and Maloney (1984) (2) noted that north-facing slopes at high latitudes on Callisto are bright, perhaps due to cold-trapping of ice.
- 6) Moore et al. (1996) (10) suggested that Ganymede's polar hood may be a sink for ices which sublimate preferentially from the equatorial regions.
- 7) Helfenstein (1986) (11) pointed out that retention of albedo contrasts in the polar frost caps suggests either that the caps are very thin or that cap material intermixes with and brightens the underlying regolith, and Hillier et al. (1996) (8) document that the caps are very thin at their boundaries and increase in thickness toward the poles.

Initial images obtained in the G2 light-dark boundary sequence at 45 m/pixel are shedding light on this issue. Specifically, we describe here initial observations of the terrain seen in image SO359946135 of the light-dark boundary sequence (Figure 1; image at URL <http://galileo.ivv.nasa.gov/sepo/atjup/ganymede/GG2TD>

KBD.html) located at about 56 degrees north latitude. In this image, the incidence angle is 58 degrees, the emission angle is 33 degrees, phase angle is 50 degrees, and the sun is illuminating the terrain from the south (bottom right). The image covers an area about 18 km wide. Reference should also be made to the global image at URL <http://galileo.ivv.nasa.gov/sepo/atjup/ganymede/G1global.html>, a color image obtained during the G1 encounter, where this area is barely within the northern extent of the image, but well within the polar hood.

**Observations and analysis:** The bright grooved terrain in this image is very different than that seen at lower latitudes. Instead of sharp and distinctive ridges and grooves observed in bright terrain regions such as Uruk Sulcus, the surface is dominated by a bright patchy mottled appearance. Upon closer inspection, the north-facing interiors of craters are dominated by bright material that appears to extend beyond the wall-floor interface and onto the crater floor. This is in contrast to much of the rest of the crater interiors, where more typical albedo characteristics are seen. For example, in the south-facing slopes, there is commonly a bright upper portion of the wall, and a dark lower wall with a ragged edge, suggesting downslope movement of material and debris/talus piles at the base of a relatively fresh upper wall. In addition, the north-facing slopes of the linear ridges are consistently bright. In the intervening areas between ridges and the large craters, a multitude of local slopes (smaller craters, small linear segments, etc.) also show evidence of localized brightening on the apparently north-facing slopes.

How extensive and thick are these deposits? In the large crater interiors, much of the detail that is visible in the south-facing slopes (e.g., talus and floor roughness) is not apparent in the north-facing slopes. These topographic details may have been smoothed over by the frost deposits. In addition, the arcuate nature of the northern border of the deposits on the crater floor in several cases (in contrast to the clear break in slope at the wall-floor boundary from the south-facing slopes) suggest that the deposit is not following local underlying topography and thus might be thick. The southern half of some of these craters has the appearance of a bowl-shaped crater, while the northern portion appears more similar to the morphology of a flat-floored crater. Thus, on the basis of these observations, the thickness of the deposit seems certainly to be more than mm or cm, and might be of the order of meters or more. We are presently undertaking more detailed analysis of the geometry and morphology of the crater interiors and the bright deposits.

**Implications:** The observations in the Galileo data from this site strongly suggest that there is heterogeneity in the distribution and thickness of the polar frost deposits

on Ganymede (dominantly north-facing slopes) and that local thicknesses may be measured in terms of meters and perhaps more. Regional light-dark albedo boundaries are apparent at the Voyager scale, but are obscured at the Galileo scale. The overall brightening of the polar hood may be dominated by the integrated effect of the bright mottled deposits. More quantitative observations and further modeling using the Galileo observations are underway, as are stratigraphic analyses to assess the timing of frost emplacement. Mass balances are being estimated on the basis of further analysis of the thicknesses of the deposits and their areal coverage.

**References:** 1. Squyres, S. (1980) Surface temperatures and retention of H<sub>2</sub>O frosts on Ganymede and Callisto, *Icarus*, 44, 502-510; 2. Spencer, J. and Maloney, P. (1984) Mobility of water ice on Callisto: Evidence and implications, *Geophys. Res. Letts.*, 11, 1223-1226; 3. Shaya, E. and Pilcher, C. (1984) Polar cap formation on Ganymede, *Icarus*, 58, 74-80; 4. Johnson, R. (1985) Polar frost formation on Ganymede, *Icarus*, 62, 344-347. 5. Shoemaker, E. et al. (1982) The geology of Ganymede, in *Satellites of Jupiter*, Univ. Arizona, 435-520; 6. Purves, N. and Pilcher, C. (1980) Thermal migration of water on the Galilean satellites, *Icarus*, 43, 51-55; 7. Sieveka, E. and Johnson, R. (1982) Thermal and plasma-induced molecular redistribution on the icy satellites, *Icarus*, 51, 528-548; 8. Hillier, J. et al. (1996) Latitude variation of the polar caps on Ganymede, *Icarus*, 124, 308-317; 9) Spencer, J. (1987) Thermal segregation of water ice on the Galilean satellites, *Icarus*, 69, 297-313; 10. Moore, J. et al. (1996) Mass wasting and ground collapse in terrains of volatile-rich deposits as a solar-system wide geological process: The pre-Galileo view, *Icarus*, 122, 63-78; 11. Helfenstein, P. (1986) Derivation and analysis of geologic constraints on the emplacement and evolution of terrains on Ganymede from applied differential photometry, PhD. Thesis, Brown University, 414 p.

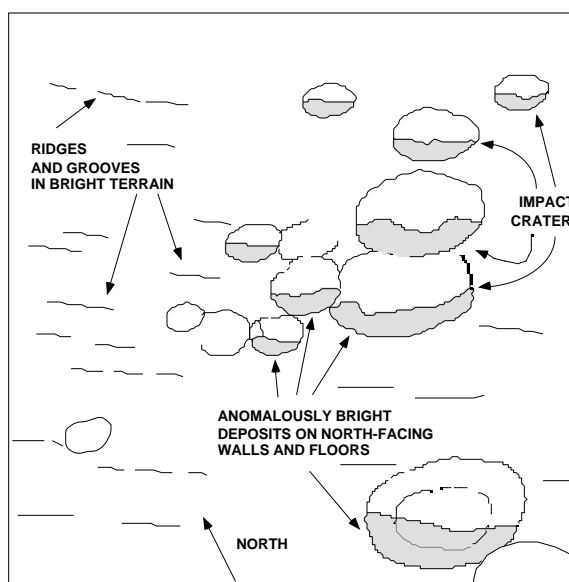
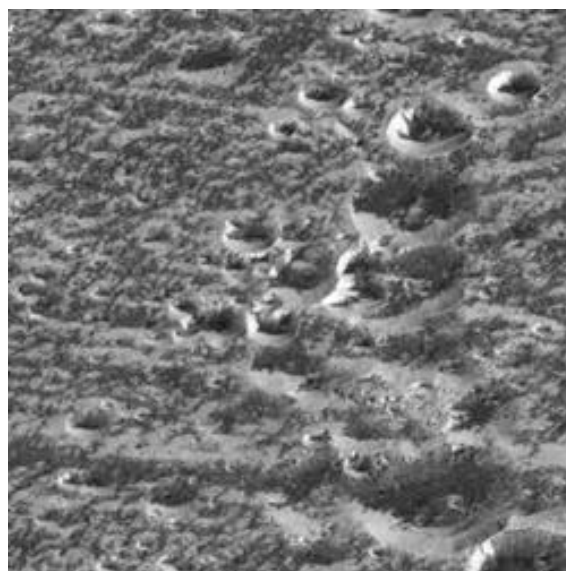


Figure 1.